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PATENT APPLICATION OF

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ENTITLED

MAGNETIC FLOW METER WITH REFERENCE ELECTRODE

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MAGNETIC FLOW METER WITH REFERENCE ELECTRODE

FIELD OF THE INVENTION

The present invention is related to the process measurement and control industry. More specifically, the present invention is related to magnetic flow meters.

BACKGROUND OF THE INVENTION

Magnetic flow meters are used to measure flow of a conductive process fluid through a flowtube. The conductive fluid flows past an electromagnet and electrodes. In accordance with Faraday's law of electromagnetic induction, an electromotive force (EMF) is induced in the fluid due to an applied magnetic field. The EMF is proportional to the flow rate of the fluid. The electrodes are positioned in the flowtube to make electrical contact with the flowing fluid. The electrodes sense the EMF that is magnetically induced in the fluid which can then be used to determine flow rate. The EMF is measured by the flow meter using a differential front end amplifier connected across the electrodes. The potential of the process fluid is used as a reference for the differential amplifier. Note that this reference may not necessarily be Earth ground.

The transmitter must be referenced to the process to provide a stable reading. This process connection is established by insuring electrical connection between the flowtube and the process. This can be done with

ground rings which strap to flowtube, a ground electrode which is connected directly to the flowtube, or a strap between the flowtube and the adjacent conductive pipe. Earth ground can provide a low noise reference and often is required by electrical safety code. However, earth ground is not necessarily required for proper operation. Some installations due to the electrical nature of the process or the corrosiveness of the process fluid use either plastic or non-conductive pipe or a lining in the metal pipe. In these cases, the process may be at a different electrical potential than earth ground. The connection between the ground electrode and flowtube through bolts or some other means can provide a path for electrical current to ground which may lead to corrosion of the ground ring or ground electrode.

In many process installations, process piping carrying the process fluid is conductive and is in contact with the process fluid. Accordingly, simply connecting a strap from the flowtube to the process piping will ensure that the conductive fluid is at the same potential as the flowtube. However, in some applications, the process piping itself may be non-conductive, or may have a non-conductive inner lining. Thus, electrical contact to the process piping itself will not establish a reference to the process fluid. In these situations, an alternative technique must be used to electrically couple to the process fluid. For example, a process reference can be accomplished by

using either ground rings or a ground electrode within or adjacent to the flow meter.

One of the problems that has occurred in magnetic flow meters in accordance with the prior art is significant corrosion of ground electrodes. The connection between the ground electrode and flowtube through bolts or some other means can provide a path for electrical connection to ground which may lead to corrosion of the ground ring or ground electrode. In installations where ground electrodes tend to corrode, the flowtube can be electrically isolated from earth ground to remove the electrical path to ground. This will generally prevent any electrical current from flowing through the process fluid and the ground electrode to earth ground. While this approach has generally resolved many problems, it has not addressed all situations.

Some situations continue to exist where it is not feasible to isolate the flowtube from ground due to the particular application. One example of such a case is where the bolts themselves used to install the flowtube provide an electrical path between the flowtube and the adjacent process piping. Another example is the use of metal lined pipe which prevents isolation of the flowtube from adjacent piping. However, this will likely provide some path to earth resulting in stray current corrosion of the ground electrode or ground ring. In such environments, grounding rings can be used. Grounding rings provide a greater surface area in

comparison to a ground electrode and the corrosion is much less problematic. However, in some situations, ground rings are impractical. For example, the failure of a ground ring can result in leaking of the process fluid. Further, the use of an inert metal such as platinum is expensive. Accordingly, providing a magnetic flow meter with a ground electrode that can resist corrosion and is less expensive than ground rings would be particularly useful in some installations.

SUMMARY OF THE INVENTION

A magnetic flow meter includes circuitry that is adapted to be electrically coupled to a process fluid. A reference contact is configured to contact the process fluid flowing within a flowtube. An electrical component is provided in series between the reference contact and the circuitry to reduce the flow of electrical current through the reference contact.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partially cut away view of a magnetic flow meter in which embodiments of the present invention are particularly useful.

FIG. 2 is a diagrammatic view of a magnetic flow meter in which embodiments of the present invention are particularly useful.

FIG. 3 is a diagrammatic view of a portion of the flowtube for use within a magnetic flow meter in accordance with an embodiment of the present invention.

FIG. 4 is a diagrammatic view of a magnetic flow meter in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A magnetic flow meter is disclosed that provides increased ground electrode corrosion resistance in response to stray currents present in the process. In particular, embodiments of the present invention act to limit, or other inhibit, stray currents present in some process installations from flowing through the ground electrode to ground.

FIG. 1 is a partially cut away view of an embodiment of a magnetic flow meter in which embodiments of the present invention are particularly useful. Magnetic flow meter 20 includes a flowtube 22 formed of low magnetic permeability material with an electrically insulating liner 23, an electromagnet 26 is formed by a coil, a ferromagnetic core or shield 28 and electrodes 30, 32. The electromagnet 26 and the electrodes 30, 32 are wired to a transmitter circuit 34 as is ground electrode 35. In operation, the transmitter circuit 34 drives the electromagnet 26 with an electrical current, and the electromagnet 26 produces a magnetic field 36 indicated by arrows inside the flowtube 22. Process liquid 21 flows through the magnetic field in the flowtube 22, and the flow induces an electromotive force (EMF, voltage) in the liquid 21. The insulating liner 23 prevents leakage of the EMF from the liquid 21 to the metal flowtube 22. The

electrodes 30, 32 contact the liquid 21 and pick up or sense the EMF which, according to Faraday's law, is proportional to the flow rate of the liquid 21 in the flowtube 22.

FIG. 2 is a diagrammatic view of circuitry of a prior art magnetic flow meter. The magnetic flow meter 120 includes a flowtube 124 that has an insulated liner 126 adapted to carry a flowing liquid 128 that is electrically coupled to the flowtube 124 and is generally connected to earth ground 130. When the process piping is electrically coupled to the process fluid, an electrical connection between the piping and the flowtube provides the required electrical coupling of process fluid 128 to the flowtube. Coils 134 are positioned to apply a magnetic field to the process fluid in response to a drive signal from drive circuitry 152. Electrodes 138 and 140 couple to measurement circuitry 154 through amplifiers 150 and 148, respectively. Measurement circuitry 154 provides an output related to flow in accordance with known techniques.

As illustrated in FIG. 2, components within magnetic flow meter 120 are typically coupled to a common reference. For example, amplifiers 148 and 150 are referenced to a common reference which is connected to flowtube. This allows the transmitter to eliminate noise common to each electrode with reference to the process.

The configuration illustrated in FIG. 2 works particularly well where the process piping itself is metallic and thus can be connected directly to flowtube providing a strong electrical reference to the process fluid. There are however some situations where the process piping does not provide an electrical reference to the process. Specifically, some process installations use non-conductive piping or use conductive piping with non-conductive inner linings. In these cases, it is still important for the front end amplifier to be reference to the potential of the process fluid. This is because while the potential of the process fluid may vary significantly depending on stray currents, and/or interference, the potential measured across the electrodes 138, 140 is typically on the order of one or more millivolts. In these cases, a third grounding electrode is used with the magnetic flow meter. This grounding electrode is used to electrically contact the process fluid. However, in some installations, corrosion of the grounding electrode occurred unacceptably rapidly. The invention includes the recognition that excessive corrosion of the ground electrode can be caused by stray currents present in the process fluid which are shunted to ground through the electrode. For example, some processes require application of large potentials or electrical currents to the process fluid which may leak through the ground electrode.

FIG. 3 is a diagrammatic view of a portion of a flowtube for use within magnetic flow meter in accordance with an embodiment of the present invention. Portion 200 of flowtube includes a pair of electrodes 138, 140 extending through conductive casing 202 via non-conductive couplers 204, 206, respectively. Electrodes 138, 140 further extend through non-conductive lining 208 such that each of the electrodes 138, 140 electrically contact the fluid flowing within portion 200. Electrodes 138 and 140 couple to circuitry 198 (shown in FIG. 4) through connectors 222 and 224, respectively. In FIG. 3 , ground electrode 212 passes through case 202 via a non-conductive coupler 214 which is preferably of a similar type of couplers 204 and 206. However, any manner of passing an electrically conductive electrode through conductive casing 202 in a non-conductive manner, or otherwise providing electrical access to the interior of case 202 while isolating electrode 212 therefrom can be used. Ground electrode 212 is coupled to circuitry 198 (shown in FIG. 4) through a current limiter 216 and connection 225. In one embodiment, current limiter 216 is simply a resistor. However, any device, or circuit which can function to limit or reduce the current component passing therethrough can be used to practice embodiments of the present invention. Preferably, current limiter 216 allows the potential of the process fluid to be coupled to measurement circuitry 198. Accordingly, current limiter 216 can include a filter

or other electrical component or circuit. Additionally, while FIG. 3 illustrates simply one ground electrode 212, any number or configuration of such electrodes can be used in order to spread the corrosion over a plurality of such electrodes. In some embodiments, the ground electrode 212 can comprise a ground ring.

FIG. 4 illustrates a magnetic flow meter 300 in accordance with an embodiment of the present invention. Components which are similar to components shown in Figure 2 are numbered the same. The flowtube includes a ground electrode 212 that is operably coupled to amplifiers 148, 150 through current limiter 216. Accordingly, the output of amplifiers 148, 150 are referenced to the potential of the process fluid.

Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention. Typically, when a resistor is employed for the current limiter, its resistance will be between 10 ohm and 50kohm, however, any appropriate value can be used, for example 100 kohm, 150 kohm or more. The ground electrode can be of any appropriate material such as platinum. The current limiter can be an integral component of the ground electrode, for example by adding impurities to the electrode or fabricating the limiter with the electrode.